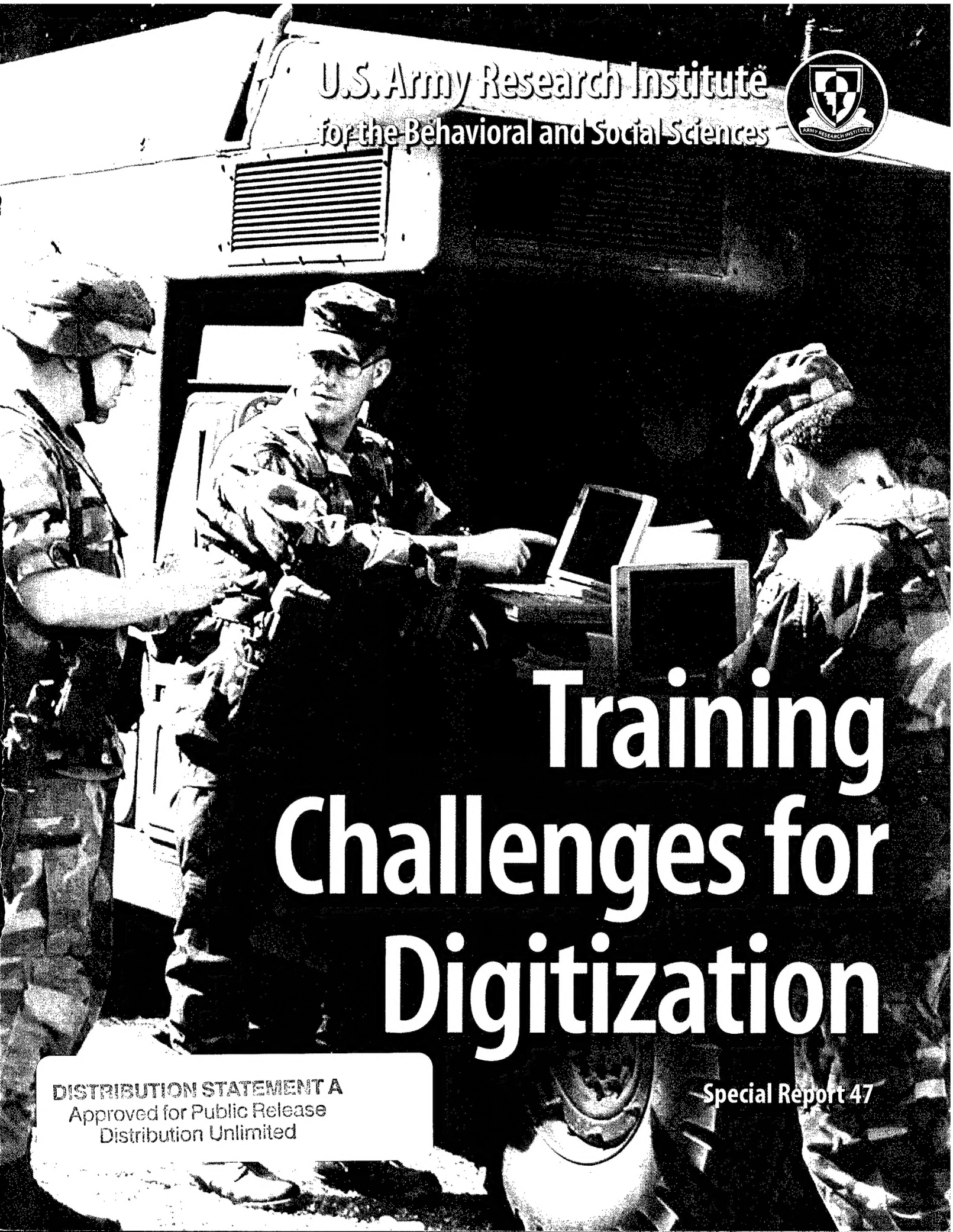

U.S. Army Research Institute
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Training Challenges for Digitization

Special Report 47

Training Challenges for Digitization

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Foreword

This Special Report from the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) reviews the challenges of how best to train computer-based digital skills required for future battlefield operations. It explains the foundation of Army needs, the state of current knowledge, suggests research to address the most pressing needs, and outlines the potential benefits to the Army. The goal is to communicate these challenges to training managers and leaders who have to make informed decisions about how to support training for the Objective Force and the future Army.

ARI personnel derived the challenges from several sources. Training researchers reviewed official and unofficial documentation and reviewed the scientific literature about digital skills training, retention, and related topics. ARI research units co-located with TRADOC schools interacted with school personnel to understand digitization from their perspective. Current experience with digitized systems was gained from interviews conducted at Fort Hood, Fort Huachuca, and Fort Drum. Fort Hood is the home of the 4th ID (M), the first digital division. The U.S. Army Intelligence Center (USAIC), a long-time user of digitization, is at Fort Huachuca. Digitization is beginning at Fort Drum within a light infantry brigade. ARI scientists reviewed digitization perspectives at a Workshop in 1999 that began the job of organizing the challenges represented in this report.

EDGAR M. JOHNSON
Director

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Digitization and Training in the Future Army

COL Jones is evaluating his first moves to deter invasion of a friendly nation. His combat team is deploying as the initial elements of a highly mobile combat force. Their deployment will enable defeat of the invasion force if required. Each soldier sees the battle area on personal displays, each one tracks own and opposing forces, and each one can interact through an information network.

The capabilities of COL Jones and his future force in 2015 are heavily dependent on computers and robots. Their training with a family of digital systems and networks includes suites of advanced sensor systems and control of direct/indirect fires. The latest RPVs and satellite downlinks give near real-time data about our own and hostile forces. Sensor reports to date show hostile action has been characterized by battalion size raids and support to insurgent forces. Some combat cells, as they now are called, have closed in the theater with reconnaissance, infantry, standoff robotic artillery, and a multi-cell distributed command post. COL Jones' mission is to defend well forward from the lodgment, cover the deployment of follow-on friendly forces, and be prepared to initiate offensive action against the threat should the invasion force cross the border.

COL Jones' staff – some elements airborne en route, some still at home station, and some at a mobile tactical command post – do parallel planning and information sharing through digital networks connected to staff in theater and subordinate elements. The combat team uses an information structure linked through horizontal and vertical networks that enable detection and destruction of the enemy at a distance. The same information structure rapidly informs the combat team about the constantly changing situation. Having advanced systems provides a technology edge to the friendly force, but technology alone does not win battles.

Success depends on each soldier's proficiency with a network of digital systems. Multi-skilled training allows soldiers to horizontally integrate their actions with team members from other branch disciplines and cells. For example, Threat Situation Analysts must develop fire support options cooperatively with Direct/Indirect Fires Officers. To fight

and win, responsibility for parsing information occurs at many levels with only split seconds for responding to changes in a situation.

The flattened organizational structure created by widely dispersed individuals and cells mandates more responsibility at lower levels. Soldiers and leaders must be proficient and current in equipment employment, operation, and maintenance. They "train on demand" through an embedded capability or from a satellite download using the network. More junior soldiers rely on skills in decision-making aided by automated tools and checklists. Even mid- and junior-level soldiers can understand different levels of the commander's intent and his operational priorities, all of which place added burdens on training.

As the situation progresses, the combat team's Threat Situation Analysts focus on the potential leading edge of the invasion force since the initial alert. The multi-system all-source update confirms that the threat has repositioned forces in reaction to COL Jones' deployment. Penetration of the border could occur with no notice.

The alert on COL Jones' command display comes with an ominous voice that barks "warning" accompanied by a flashing screen. A light and highly mobile two-man outpost is operating 15 kilometers from the forward line of friendly positions. Using remotely positioned monitoring devices, the outpost detects a large threat unit approaching the border. The Threat Situation Analysts check real-time images being received from higher-level assets and quickly note a double thrust of the threat. Three truck-mounted regiment-sized units are headed toward the capital, and one mechanized brigade with truck-mounted infantry is aimed at the combat team. Who constitutes the opposing force in unclear. In the world economy, it has been easy for countries to purchase NATO equipment and outfit it with state-of-the-art sensors and armament. Friend-foe

identification now depends not on identifying the silhouette of the vehicle but on use of the Identify Friend-Foe (IFF) system built into the network signatures of our forces. By choosing to mute displays of our vehicles, COL Jones can identify on his surveillance screen two armored and heavily armed hostiles moving in dust through the rolling terrain. The follow-on threat formations beyond direct line of sight of forward reconnaissance cells are confirmed and located by remote sensor arrays.

COL Jones' combat team reacts immediately based on prior planning and practice for multiple contingencies. Simultaneously, coded orders issued from his combat console prompt all subordinate cells to take action. Teams and staff are skilled in collaborative tasks in addition to individual tasks. These personnel typically are located over long distances and do not have the luxury of face-to-face coordination. They have selected sites to provide effective interfaces with the digital network and survivability against a broad array of threats. The different participants are linked to provide real-time information sharing to properly train and prepare for operations.

Being a light and highly mobile force enables the combat team to deploy rapidly but still engage in full spectrum conflict over a large territory with rolling hills, scattered villages and a few towns, and groves of trees. Junior leaders, operating independently, use digital systems to maintain information flow and situation awareness. They possess the tactical knowledge to accomplish missions per the commander's remote guidance. In one action, a captain in charge of a 100-soldier cell dispersed over 10 kilometers is charged to delay the enemy force. He verifies his operational and logistics status using map displays and information garnered from the network. As the battle commences, the captain avoids the necessity of last minute or additional support requirements, given that his self-sustaining cell and the digital network "see" logistical readiness.

Overview of The Training and Research Challenge

Certainly, this new way of conducting Army operations presents many challenges to leaders and soldiers. A significant challenge to the training community is how to make this future battlefield work and sustain its complex readiness. What advice does the Army need about how to handle training for digital operations as it transforms itself into the Objective Force?

To create a balanced system, the Army should both develop information-age materiel with accompanying doctrine and organization and changes in training and leader development. For example, there will be an increasing need for adaptive leaders to cope with unexpected and rapidly changing situations (Ervin and Decker, 2000). As another example, there will be a need for soldiers who understand and perform functions for more than one duty station, i.e., training must result in soldiers who are digitally proficient, multi-skilled, and adaptable.

The role of research is to develop the training technology to meet the digital task training requirements for soldiers to do their jobs using computer systems with multi-functional windows-type operating systems and menus. Learning "knobology" – what keys and menu items map to different functions – is a small part of using the system. The emphasis must be on training soldiers in skills for mission execution including adaptability to change. They become familiar with different duty assignments within their branch, and learn how their duties fit in with other branches and how to shift

emphasis as needed to work as digitally-linked teams. Training technologies must support workstation-to-workstation operating requirements, even across branches. The targeting function, for example, depends on horizontal and vertical integration of information between the ground force commander, his intelligence staff, supporting engineers, and the indirect fire assets (artillery, AF, and Navy.) In addition, soldiers' jobs include skills for routine workstation maintenance and how to troubleshoot day-to-day operating problems.

From officers to system operators, the digital environment needs emphasis on training assessment and feedback to ensure proficiency. The Army has to train soldiers to "see the battle," understand it, and share it through their computers and computer screens. This only will be possible with training on demand so soldiers can be proficient on the job they must perform presently.

In summary, COL Jones has the digital systems that have been proven to provide a technological advantage. However, his greatest challenge is to ensure soldiers are trained properly and effectively to employ these systems.

Background

The Army is greatly increasing its use of weapons, equipment, and technologies that depend on soldiers and leaders with information-age, digital skills. The Army Digitization Report 2000 (Army Directorate of Integration, 2000), emphasizes the advantage of advances in information technology throughout the battlespace, and defines digitization as shown in the shaded box. The benefits of digitization are for all personnel – users, managers, maintainers, and sustainers – with the particular emphasis here on users. The right training is important to help prepare for the decentralized, fluid, fast-paced operational strategies and tactics of the Objective Force. How should the Army train to sustain the skills necessary for multi-faceted military operations, including peacekeeping and security missions, using digitization, its equipment, software, and procedures? Most critical is research on how to train soldiers and teams of soldiers to: 1) seek out, identify, and analyze information, 2) cope with information overload, 3) operate as components in networks of digital systems, and 4) make wise individual or collective decisions. The Army needs to determine how to best train what, where, and when.

Digitization applies information technologies to acquire, exchange, and employ timely data throughout the battlespace . . . [that] . . . will allow all friendly forces to share a constantly updated view of the entire battlefield, no matter what the mission, to penetrate the enemy's decision loop, and act faster than he can react.

— The Army Digitization Report 2000, June 14, 2000

Training must evolve as technology changes the ways soldiers fight, from the infantryman to the highest levels of command. For example, preparing infantrymen for close combat now involves individual marksmanship, bayonet, and hand-grenade training. In the not-too-distant future, that same infantryman will be much more removed from close proximity to the enemy. The Land Warrior "foot soldier" can be a weapon system. Training him in squad tactics now involves line-of-sight hand and arm signals. Future

tactics may have him separated from other soldiers by kilometers as he digitally controls robotic weapons systems by using a helmet-mounted situation display, a visual sensing device, and a keypad. New digital technologies can remove the more senior NCOs and officers even further from their traditional places on the battlefield, making warfare increasingly abstract at higher levels of command.

Commanders of digitized units, as well as other observers, state that training in battlefield digitization systems is broken. The Army has spent billions on these systems, and it has been estimated that units are getting only a small amount of the potential increased effectiveness.

Younger, less experienced leaders need to train "how to think" and adapt at increasing levels of abstraction.

Figure 1 was modified from one used by GEN (Ret.) Vuono to brief senior Army trainers. It shows that the Army of the near future will fight "over the horizon." Those major changes must bring changes to training technologies. Broader mission responsibilities – peace keeping, peace making, and conducting combat operations – increase the complexity of what needs to be trained. In addition, the level of abstraction, separation, and detachment will be greater for soldiers and leaders. They will be removed in space more than ever before from each other, the systems they control, and the enemy they engage. The Army's "zone of research" for this effort starts now through 2008 with fielding the first unit equipped, and continues beyond. Although specific changes are unknown in both fighting and non-fighting missions, current indications certainly provide major opportunities for new and innovative training research and training.

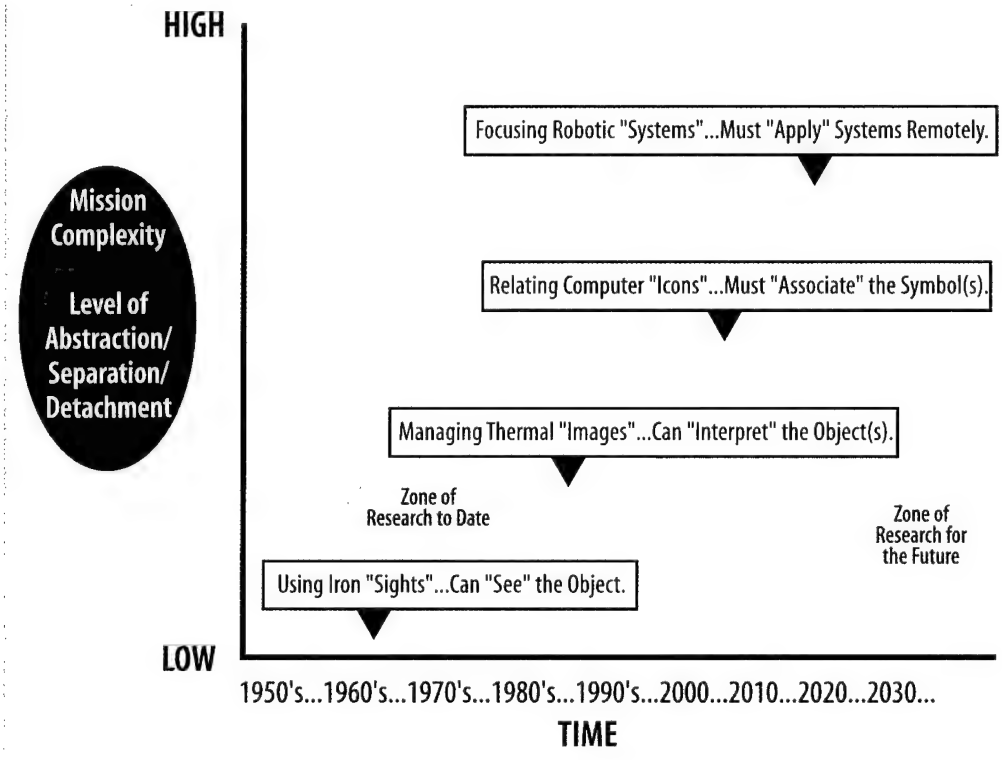


Figure 1
Changes resulting in the need for research: How the Army fights.

Leveraging Technology

People often are told that digital tools and devices, including the computer, will help them do a better job. As with other technological innovations, digitization initially was introduced to improve job performance over existing technology. For example, the word processor was accepted as a better typewriter, the computer as a faster calculator, and so on. However, there are reminders from experts that technologies may be a problem instead of a solution particularly for managing information. In his book about the trouble with computers, Landauer (1995) points out that fully automated systems where the human operator is replaced, as with telephone switching operations, are highly successful and increase productivity. In contrast, systems to augment, aid, or assist the human operator may not enhance productivity because of problems with software design, user interfaces, and operational deployment. Martinsons and Chong (1999) point out that the full benefit of information systems is realized only if tailored to the user's need and environment. Without redesigning the tasks and processes, automation is not enough. Then too, with automation of information systems comes the growing problem of information overload, which can make it harder to determine the right solutions or make the correct decisions.

To realize the potential power from digitization, the equipment needs to be interconnected and utilized in new performance-enhancing ways. It takes time for new technology to develop to a high level of quality and dependability. At that stage, design changes and special features accomplish old things in better ways or make new uses possible. For instance, the airplane was selected for use in World War I as an improvement over the observation balloon. It was later that the airplane had armaments added to become an early version of a fighter-bomber. However, it was not until the next decade that General Billy Mitchell sank a battleship with bombs from an airplane. Similarly, the effectiveness of digital technology is a function of many factors. Improved training, one of the major factors, is diagrammed in Figure 2.

People need training designed to achieve full performance through use of technology. Current evidence for that concept comes from results of the first digitally equipped units during their advanced warfighting exercises. Expert observers state that units' performance showed them doing old things only a little better and showed them starting to use the digital technologies in new ways. However, they get very little increase in effectiveness because the training to go along with that technology has not kept pace. Feedback from these exercises showed that NCOs and officers had problems determining how to best train their soldiers.

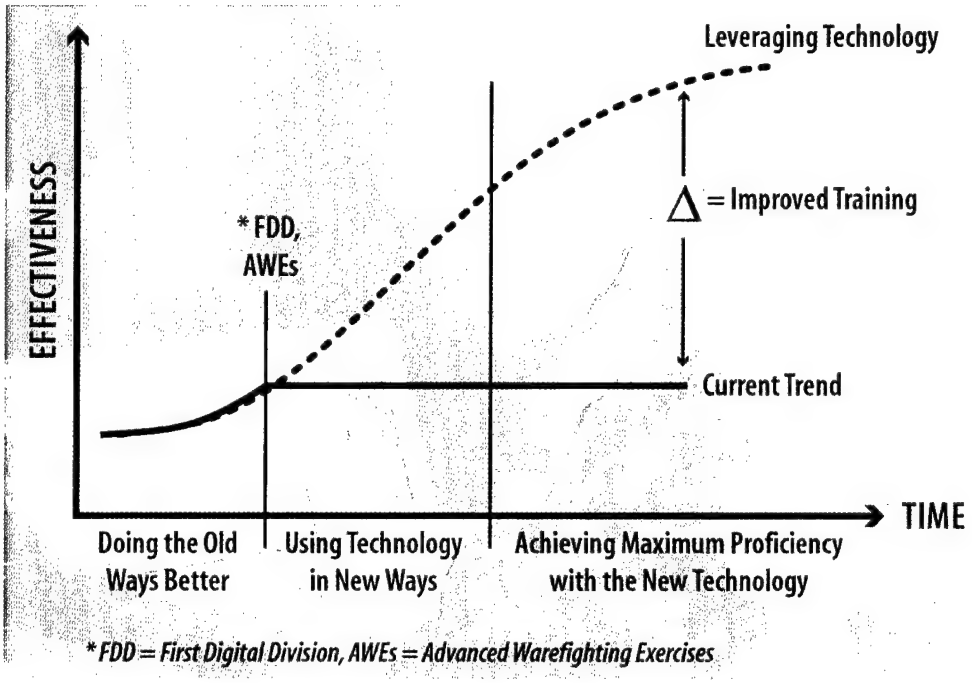


Figure 2
Changes resulting in the need for research: technology the Army uses.

Structuring the Challenge

Research should identify training principles and methods for digitized operations and procedures that maximize skill acquisition, utilization, and retention. There are a number of identifiable issues, questions, and gaps concerning the training of digital skills. Issues may exist at more than one level of task complexity, from computer keyboard and software use to command skills (see Appendix A). However, there is a question about what effects digital equipment and procedures have on training.

Training technology must prepare the warfighter to handle data from digital platforms such as satellites, Joint Surveillance/Target Attack Radar System (JSTARS), and Unattended Aerial Vehicles (UAVs) that supply hundreds of messages per minute to command and control workstations such as the All Source Analysis System (ASAS), Maneuver Control System (MCS), and Advanced Field Artillery Tactical Data System (AFTADS). Leaders and staffs must learn to sort through this flood of data (messages and imagery), process it into information (intelligence), distribute the information across workstations and echelons, and then decide on courses of action. Their task will be complicated in hybrid operations where digital and "manual" modes of operation co-exist or where digital systems across echelons are incompatible.

Training Challenges for Digitization

Training needs to accommodate missions characterized by: 1) an extended operational battle space that goes beyond width, depth, and height to include the electro-magnetic spectrum, 2) precise and synchronized attacks throughout the battle space, and 3) non-linear, distributed, and simultaneous operations. In these ill-defined, unpredictable environments, soldiers and leaders will not find all the answers to tactical problems in existing doctrine. They must have experience in discovering or even inventing solutions (Assistant Secretary of the Army, 1999; HQ, US Army, TRADOC, 1998). The kinds of challenges are illustrated in Figure 3.

Figure 3
Changes that challenge training

- *Time and resource limitations demand that training of digital procedures and skills – including back-up and work-around skills – are integrated into training of tactics, techniques, and procedures.*
- *The volume of ambiguous data, along with smaller operational units and novel situations, require methods for training junior and mid-level soldiers to be flexible and adaptive.*
- *Frequent upgrades in digital system hardware and software limit learning of skills to mastery levels and place great demands on refresher training.*
- *Future operations call for widely dispersed soldiers linked through electronic networks to perform as digital teams with new training demands (e.g., advanced distributed learning, asynchronous simulations, and collaborative environments.*

The result of a properly trained digital force will be much more than an Army equipped with new systems. Digitization can enable the Army to achieve information dominance, the key to success for operational changes planned over the next 25 years. Digital systems will allow soldiers to acquire, process, exchange, and employ data and information throughout the operational battle space. These systems will provide the basis for operational skills at every level from target identification and acquisition to situational awareness and command decision-making.

ARI identified major stakeholders and customers who could identify training challenges for digitization (summarized in Appendix B). HQ, U.S. Army Training and Doctrine Command (TRADOC), a key stakeholder, needs training modernized to fit the information age. Commanders and leaders in the field who are receiving new digital equipment, as well as Army schools and centers within TRADOC, are also stakeholders who need to adapt to digitization. Senior Army leaders are stakeholders concerned with readiness and costs. We used these stakeholder interests, and how the Army must respond with new training technologies as the basis for structuring the challenges.

Digitization Challenges and Research

ARI researchers chose an overarching framework to summarize content areas and focus on high priority topics. It was important that the framework cover topics already approved by stakeholders such as HQ TRADOC and Army schools. Good principles of training remain the same. The Army describes requirements for training in Chapter 1 of "Training the Force" (FM 25-100, 1988). Underlying this approach is an extensive literature about how to train. There are many excellent summaries of what works in teaching and learning, with two books of particular note (Bennett, 1986; Naval Personnel R&D Center, 1987). The emphasis here, for digitization, falls under three broad areas: Requirements for Soldier/Leader Capabilities, Training Methods, and Training Delivery. Training Methods include three important sub-areas covering training adaptability (individual), team training, and assess-skill levels. The resulting five topics (Figure 4) are elaborated in the following paragraphs.

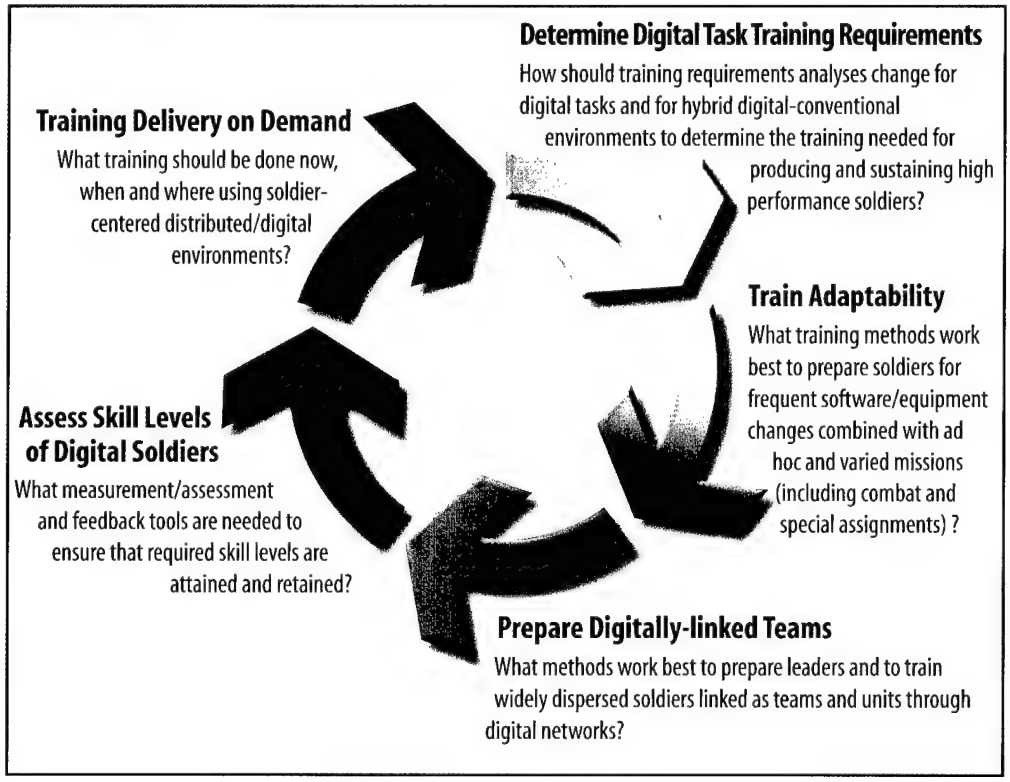


Figure 4
Five training challenges for digitization

Determine Digital Task Training Requirements

The Challenge

Among the more critical training requirements associated with digitization and the down-sizing of the military is the need for soldiers to operate in multiple arenas with the help of distributed learning and digital skills. That raises the question of how training requirements analysis should change to foster high performance organizations, leaders, and soldiers. The challenge is to determine the kinds of demands that digital

operations and procedures create for tactics, techniques, procedures, task performance, and cognitive/operational skills. One of the results of digitization may be to change the nature of lower-level procedural jobs to become more open-ended. Training requirements and standards for such jobs are difficult to establish. Soldiers will need to develop innovative thinking for responding to ad hoc military missions and objectives that are assigned with limited lead-time. To perform well in different missions, soldiers will need skills that easily are applied to multiple situations and conditions. In addition, what are the training requirements for digital staffs, nodes, and networks with no tradition or tested doctrine? And eventually, what are the training requirements for a broader population that incorporates Active and Reserve Components, other governmental agencies, and non-governmental organizations? We need to determine what to train, who to train it to, and what the workload demands will be.

Challenges in Determining Digital Task Training Requirements

- *Analyzing missions in terms of tasks and standards for soldiers and leaders.*
- *Defining innovative thinking skills needed for ad hoc missions, objectives and greater responsibilities.*
- *Identifying skills needed by multifunctional soldiers with cross-disciplinary MOSs.*
- *Identifying differences between digital and non-digital environments.*

Background

What is needed to articulate job tasks for digitization? Some initiatives, such as building Military Intelligence Combat Assessment Tables (MICATS), are going in the right direction. However, more definition of task requirements for digital operations must be developed. We do know that the lower grades tend to need training on the operation of specific equipment while the higher grades and leaders need training on integrative digital skills and software for them. Staff personnel, in particular, report spending inordinate amounts of time on electronic mail and briefings. When software changes occur, most of the training is obtained through exploring new program features, asking peers, or asking an expert if one is available. How should the Army deal with exploration to include it as part of the conditions and standards for digital operations? The challenge is growing with increases in new digital systems projected for fielding with associated MOS changes.

Research Solutions

- *Document digital skills for exemplar systems and related skills needed to cooperate with non-digital environments.*
- *Define digital task attributes and their workload levels and performance standards.*
- *Apply task and workload analysis techniques to digital systems and procedures for:*
  - *multifunctional soldiers and their span-of-control.*
  - *teams operating as nodes in digital networks.*
- *Identify basic competencies that can be bundled together as generic and key digital skill competencies applicable to multiple situations and conditions.*
- *Produce prototype methods and techniques for general application in establishing digital task requirements.*

Train Adaptability (Individual Training)

The Challenge

The future military environment will demand dramatically new types and levels of individual soldier and leader capabilities. The grease pencil and acetate will give way to the Army Battle Command System (ABCS) and the Future Combat System (FCS). Soldiers will have to go beyond minimal operation of digital workstations to be effective. For example, a battle captain with digital operations must understand the range of capabilities of the systems he oversees (e.g., ABCS and Force XXI Battle Command Battalion/Brigade and Below [FBCB2]). This understanding is difficult to acquire and is believed to be very perishable. Skill sustainment will be threatened further by rapid changes in technology that require frequent skill upgrading. However, degree and type of digitization will vary within and across organizations. As a consequence, communications among digital systems will be a problem and personnel transferring will need to retrain. We need to know what training works for frequent changes of software or equipment and the Army's varied missions.

How does the Army prepare individual soldiers and leaders to cope with the extraordinary changes described above? It still has to train the traditional warrior technical (tactical and MOS) skills. However, the Army must also develop the cognitive/operational skills needed for the non-linear, asymmetric, mixed intensity environments. The highest stage of training probably only is attainable when soldiers employ systems as an extension of their own thinking. How can soldiers achieve increasing stages of proficiency and maintain them over time? The traditional questions (what, how, how often, and when) raised about instructional design still are appropriate. The traditional questions about transfer, retention, and adaptability of training also still are appropriate. The questions are the same but the answers may be very different.

Soldiers and leaders who operate and use digital systems face several challenges, including:

- *Frequent software and equipment changes reduce proficiency.*
- *Varied missions require training methods that include combat, special assignments, and contingency operations.*
- *Everyone must learn to handle the unexpected as part of everyday events.*
- *More complex task and skill requirements reduce skill retention and sustainment.*

Background

Much of the individual skill acquisition and retention drills done today are based on performance-oriented, criterion-referenced training. This approach has served the Army well in preparing soldiers and leaders to perform highly proceduralized, structured tasks in predictable environments involving high intensity conflict. It has been characterized in TRADOC and other high-level briefings as a "what to think" approach to training. How should that change to suit the new environments and support a shift in training emphasis to "how to think"?

Research Solutions

- *Develop training methods and strategies that promote adaptive/flexible and innovative behavior for the Army's paradigm shift to "how to think" and generic skills.*
- *Determine the right mix of digital operational skills ("practice") with general task principles ("theory") in both on-line and face-to-face instruction.*
- *Determine the training methods and strategies to prepare soldiers and leaders for changing roles in the future Army.*
- *Develop tools for predicting retention of digital skills and the training methods for reducing the perishability of such skills.*

Prepare Electronically-Linked Teams (Staff and Group Training)

The Challenge

Digitization adds obstacles to and opportunities for how to operate as part of a team. The challenge is that the Army is expected to use smaller and more diverse staffs and groups in dispersed environments that depend on information exchange through extensive horizontal and vertical networks. For example, if properly trained, each staff element in an MCS/FBCB2 tactical operations center and all subordinate and supporting cells should have an accurate, up-to-the-minute picture of all friendly forces. There would be no guesswork or extrapolation on front line traces as in the past. However, elements are separated by distance and workstations and will not benefit from initial team or group development. This development traditionally results from eye-to-eye, interpersonal relationships that establish standard operating procedures, shared common frameworks, understandings, goals and priorities. What strategies are needed to train teams in this non-traditional and networked environment?

Digitization can aid the teaming process through use of networks to disseminate team information, battle structures, and changes. What it does not do is help soldiers spend time together to get to know one another and learn how to work together. That time becomes less and less available with the focus on digital integration instead of face-to-face interactions. One question is how to accelerate the rapid train up for mobilization of newly configured teams and organizations to perform a variety of missions. Another concern is to determine the types of training – for levels of competency, and adaptability – that should be performed at different times of a digitally-integrated team's life cycle. This includes guidelines and approaches for intra-nodal and inter-nodal training as well as for team leaders to enhance group motivation and coherence for sustained high levels of competence. We need to determine how, how often, and when to train for these leaders and their teams and groups to operate effectively in varying environments.

Specific challenges for teams include training to exploit extensive horizontal and vertical networks that:

- *May have incompatible equipment, software, or procedures.*
- *Mix different situations and individual mental models of problems and events.*
- *Emphasize electronic interactions that depersonalize information and its importance.*
- *Potentially isolate team members and thereby compromise teamwork and morale.*

Background

With their leaders, soldiers need to be able to quickly form teams and organizations that carry out a wide array of missions in an information-age Army. Interconnection through networks provides opportunities for training performance enhancement, developing shared understandings, and reconciling different perspectives. However, this information network is different from the traditional hierarchical control structures. What techniques and arrangements are needed to foster the fluid, non-hierarchical nature of digital operations while maintaining acceptable levels of direct or indirect control and coordination over soldiers and their actions? Further, soldiers will increasingly spend time interacting electronically instead of working directly together. What training methods are needed for them to operate as part of a virtual team while maintaining positive social relationships with physically co-located soldiers and leaders? The magnitude of the problem is huge with networks that link individual solders, weapon crews, organizations, and leaders.

Research Solutions

- *Determine how to use networks for pre-assignment training and training-on-the-go as we deploy.*
- *Teach how to operate as part of a network with standards and feedback.*
- *Develop procedures for leaders to form responsive teams through electronic networks.*

Assess Skill Levels of Digital Soldiers

The Challenge

Certifying the digital skills of soldiers and leaders is a chief reason for measuring how well tasks are performed. It also is fundamental to an understanding of sustainment of such skills. Without measurement, how do we know that a particular training approach was more effective or how do we know when to schedule refresher training? The challenge with digital systems is that so much happens in the interactions between the solder and the electronics that is fleeting, hard to observe, and difficult to assess. Instructors or leaders, after spending time with soldiers, generally can identify who has the strongest digital skills or is especially good at some aspect of digital operations. However, this ranking of soldiers is intuitive and without any specific criteria. Records of training are usually limited to course completion information, so there is insufficient schoolhouse data. Furthermore, given the newness of many digital systems, there is limited opportunity to develop subject matter experts who can assess performance levels.

Deciding how to assess skills is a major challenge, whether by soldier self-assessment, a computer program, a supervisor, or a very-hard-to-obtain skilled outside observer. Because of frequent updates in equipment and software, it is difficult to have updated tests or measures of proficiency calibrated to new standards. Likewise, it is difficult to establish a long-lived basis for any competency or skill certification. This challenge of measurement is magnified with collective digital skills of a team or group. In addition, what types of records does the Army need about digital skills: such as certification of competency, initial skill proficiency, current skill level, and so on?

Specific challenges for assessment include:

- *Feedback for soldiers involved in complex procedures with digital equipment makes performance observation difficult.*
- *Records about skill assessments and certification are vague about soldier capabilities and often out-of-date.*
- *Collective performance assessment becomes complicated when the least-skilled soldier can degrade much of the performance in a network.*
- *Dispersed teams require distributed assessment capabilities.*
- *Trained observers, current with new equipment and procedures, are rare.*

Background

Quantitative measures typically are only for speed and accuracy of performance outcomes – number of volleys, metal on target, or messages processed. Measures of speed and accuracy do not necessarily give any indication of how well tasks were performed. Observers can judge effectiveness based on discussions, interim products, and recommended actions. However, such judgments are hard to make with digitization where electrons flow simultaneously to influence many people and events. Collective digital skills of a team or group, with their many nodes and interactions, magnify the requirements for individual assessment. In addition, there are important questions about how to do assessment – soldier self-assessment, a computer program, a supervisor, or a very-hard-to-obtain skilled outside observer. When multiple sources are used, there needs to be a convergence across measures as a means of validating level of performance or effectiveness.

Research Solutions

- *Identify key digital skill competencies and measures of performance.*
- *Identify opportunities for digital systems to provide training feedback.*
- *Develop a generic, computer-adaptive Digital Skills Certification Test (DSCT) that includes measures of proficiency on key digital-skill competencies.*
- *Establish plans to embed DSCT in fielded systems and on the Internet for use "on-demand" anywhere.*
- *Establish a means to link soldiers to Army Training Support Center resources for upgrading digital skills through on-demand training.*

Training Delivery on Demand

The Challenge

Training today primarily is centered in the schoolhouse while, increasingly, training delivery "on demand" when and where it is needed would better serve the soldier. Some delivery mechanisms for making this transition are available. For example, Military Intelligence (MI) has developed a Master Analyst program, which employs a highly qualified local expert to train the trainers and assist users. In part, such a program is more of a necessity for MI because it is fully digitized and soldiers may work outside their MOS during assignments.

At the other end of the spectrum, non-digitized combat units may have little in the way of useful digital skill delivery mechanisms. For example, there may be centralized training on operating systems or application software that is offered at various times. However, the Operational Tempo (OPTEMPO) is often so high or erratic that soldiers cannot plan to attend any synchronous courses, locally or by distance learning.

Because digitization is relatively new, validated training and instructional procedures for acquiring skills are not established. The result is a lack of standards for training on demand. For example, the most appropriate and effective training delivery mechanisms, individually or in combination, at different levels of skill complexity, are not clear. The mechanisms vary from platform instruction to various types of simulations, to training occasionally embedded in operational devices, to the use of master-trainers, and to some form of distributed learning. Furthermore, a soldier may learn faster or better under some conditions than others.

Specific challenges for training on demand include:

- *Lack of best practices for training skill at digital tasks.*
- *Time constraints and facilities for scheduling and delivering training.*
- *Matching training delivery to level of task complexity.*
- *Designing training methods for soldiers to achieve skill mastery as quickly as possible.*

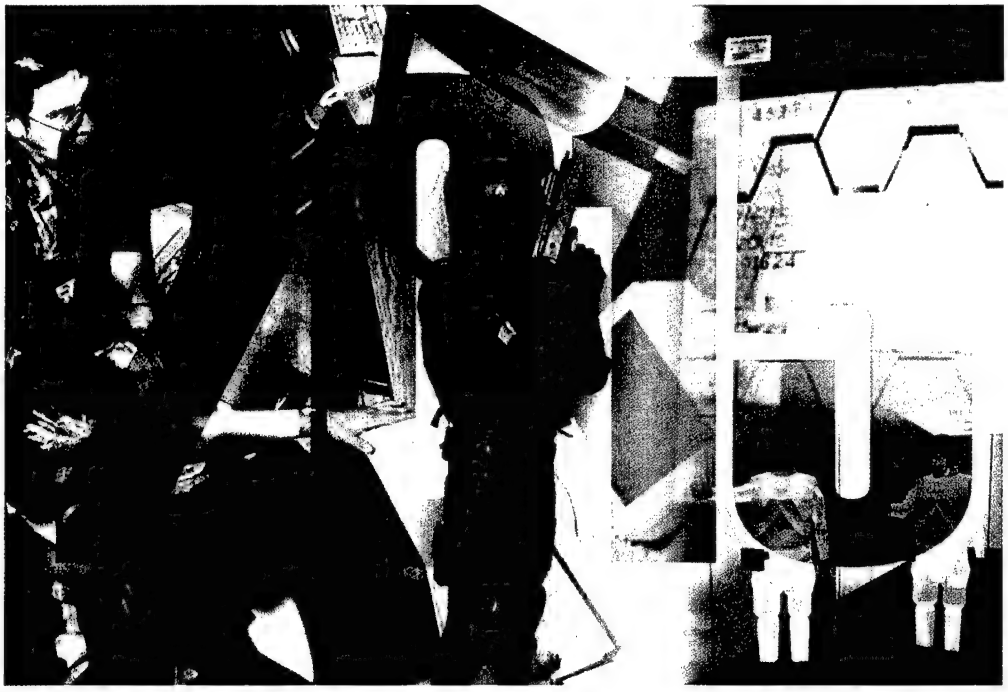
Background

Soldiers generally acquire digital skills by doing what they can and seeking help when stuck. Due to personnel turbulence and the OPTEMPO, there is limited time for collective training on digital tasks and little time or energy for self-development when the soldier returns home in the evening. As good news, many soldiers have high quality personal computers at home on which they can do adjunct training. For example, a Fall 2000 survey of active duty personnel indicated that 93% of officers and 80% of enlisted personnel have access to a computer where they live. This creates an opportunity for arranging training time at home.

Along with difficulties in allocating training, there is much unknown about new delivery mechanisms such as distributed learning. Exactly what should be taught by what distributed learning mechanism, how and when, needs clearer definition. The overall training paradigm in the Army is shifting from school-and-trainer-centered instruction to soldier-centered learning. The direct impact of this for providing training delivery and support to soldiers acquiring digital skills is unclear.

Research Solutions

- *Identify key distributed training technologies that can assist and motivate soldiers in acquiring and sustaining digital skills.*
- *Determine the role of individual preferences in digital skill acquisition.*
- *Identify solutions to organizational barriers and policies about on-demand training including at home.*



Another Factor: The Environment

The Challenge

The cycle of Army training is never complete since it must keep up with changes in the battlefield environment. That is a particularly important factor to consider in devising training for digitization.

Soldiers will have difficulty operating some systems effectively because of their design and maintenance. Changes in software and operating procedures will cause confusion. In addition, over many years to come, digitization will co-exist with predecessor equipment. Where digitization is available, information complexity can increase greatly. Soldiers will have to handle large volumes of information, understand it, know how and when to seek more or to filter it, and how and when to disseminate it. At the same time, there will be constraints such as personnel turbulence and insufficient personnel, including on-site digital experts.

These operational characteristics provide an opportunity for research on manpower and personnel integration (MANPRINT) factors in system design. Topics for attention might include: 1) designing graphical user interfaces for optimal performance and ease of training, 2) establishing equipment maintenance protocols that allow for an efficient division of labor between a user and a maintenance technician, 3) training and performance-based standardization of user interfaces and linkages between multiple pieces of digital and analog equipment within or across sites, 4) determining equipment carrying weight-to-benefit ratios and the optimal distribution of digital equipment within an organization, 5) establishing protocols for hybrid/mixed (digital and analog) equipment or degraded operations, and 6) optimizing personnel factors such as assignments, manning levels, and contractors on the battlefield.

Background

Even the most heavily digitized fields such as MI are subject to working in conditions with hybrid (digital and predecessor) equipment, and are projected to be so for the foreseeable future. This situation occurs when a digital organization is operating along with a non-digital unit, when deployment is to an area where the digital equipment cannot be used for security or other reasons, and when the digital equipment itself is inoperable. In some cases, resources are provided for thorough training of digital repair technicians (e.g., in MOS 33W). In other cases, soldiers will have to perform jobs sometimes with digital equipment and sometimes without. For example, the soldier equipped to serve as a combat system with advanced communications and weapons must also be able to perform in a degraded mode. The challenge is how to introduce digital equipment and procedures that can make a revolutionary difference and have them function successfully in the company of many conventional systems. The challenge encompasses several generic topics, including:

- Quantify the human factors variables such as performance, compatibility, and endurance and other soldier issues associated with equipment and weapons for the battlefield.
- Apply human engineering technologies and practices to the analysis and execution of logistics processes to increase responsiveness and flexibility while reducing manpower, personnel, and training costs.
- Develop tools and methodologies to evaluate the impact of soldier performance on system performance and cost.

These topics must be considered in any system design and implementation including the implementation of digital training systems indicated by research in the current reports.

A Digitization Research Strategy

Much work already has been done to define the challenge at ARI and other Army organizations as well as at MITRE, RAND, and the Institute for Defense Analyses (IDA). Research is underway to identify attributes of digital skills, to improve individual training for them, and to deliver that training when and where it is needed. Those research projects form a foundation for a comprehensive program. That program needs Army test beds and specific contexts to demonstrate the value gained from doing the work, along with ancillary research.

An as yet untried strategy is to investigate training challenges within the context of a realistic test bed, utilizing command and staff operations. Findings could be applied in other functional areas. With that in mind, the focus should be on the interactions in a maneuver unit's tactical operations center (TOC) between the S3, S2, and Fire Support Element (FSE) personnel as they train their procedures in producing operations orders (OPORDs) and as they train in the targeting process. In these procedures and processes, enemy and friendly situational awareness is greatly increased by the new digitized systems. It also is in these procedures and processes where substantial research has been done in determining existing training challenges and solutions and can, therefore, best be used for comparison purposes.

Figure 4 depicts a typical TOC. The S3, S2, and FSE staff sections are equipped with digitized systems, none of which currently is compatible with another. Each system

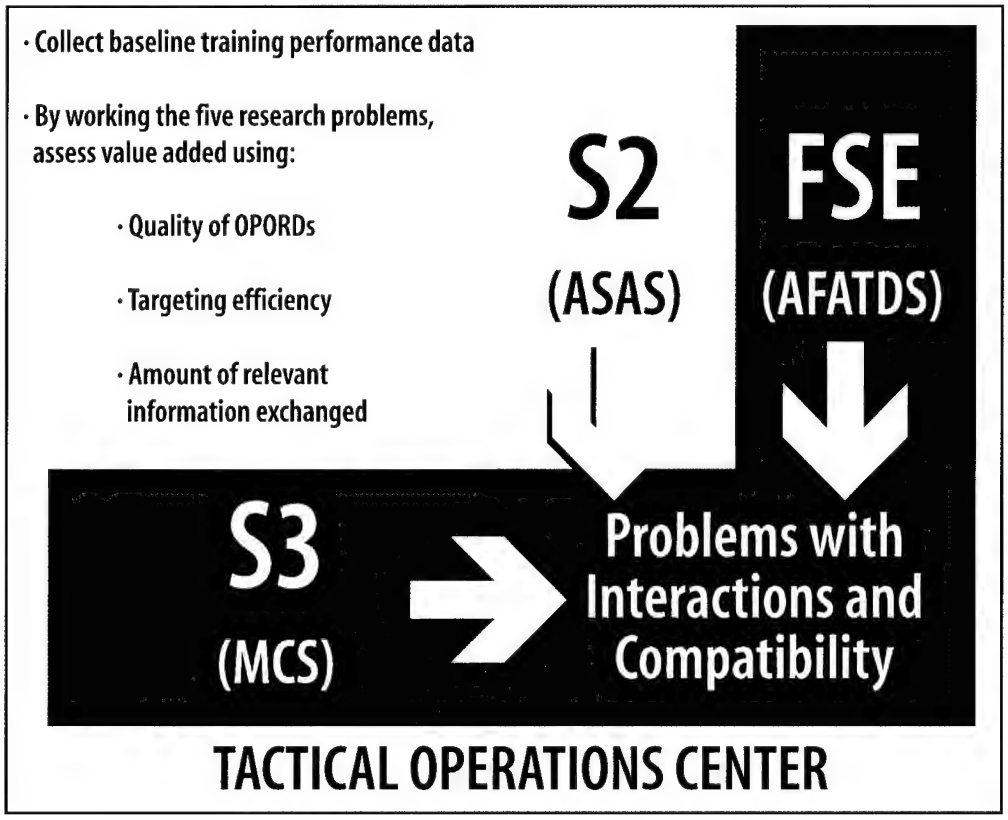


Figure 5
Test bed for training challenges.

(MCS, ASAS, and AFATADS) represents a different level of technology or a "hybrid," since none of the systems recognizes the other's outputs or inputs. In addition to the problems of compatibility between systems, there are continuous problems in training interactions of battle staffs, measuring their performance, and providing feedback for improvement. Therefore, the current TOC battle staff becomes a baseline from which data can be gathered right now to compare to more technologically advanced systems that will be trained later. Advanced techniques to address the five major training challenge areas for digitization (see Figure 3) can be tried out in the applicable organization. To find the value added by these techniques, the difference in the quality of the OPORDs produced, in the efficiency of the targeting process, and in the amount of relevant information exchanged will be measured.

Conclusion

Training practices in the Army must enable soldiers and leaders to take maximum advantage of digitization. Successful training and maintaining of digital skills presents challenges that go beyond those in traditional areas such as gunnery and vehicle maintenance. This is reflected in the often-heard statement, "Digital Skills are more perishable than other military skills." A major factor working in the future Army's favor is pointed out by COL (P) Lynch, 1st Brigade Combat Team, 4th Infantry Division, from his digitization experience: more and more soldiers entering the Army have been taught computers and can discover through experiential learning how to take advantage of them. However, the systematic leveraging of training technology is an increasingly urgent need as digital systems become more pervasive and the Army strives toward a highly proficient total force.

As work with digitization proceeds, the Army will learn more about the current command and staff training challenges and how lessons learned can be applied to other areas. One of the most important ingredients of success will be to test and get feedback about how best to train what, where, and when for the changing digitized force. As the Army assesses results at key milestones, the training technologies should be tuned to keep in synchronization with developments in Army imperatives and fielded capabilities. Digitization is new enough so that *learning as we go* is a must. Attending to this report's five training challenges for digitization will help the Army structure and pursue the goal to get maximum advantage from information technologies.

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Appendix A: Four Levels of Digitization Skills

Many new and changing demands on human performance in the Army will accompany digitization. These demands will affect training of a broad diversity of individual and collective skills for soldiers and leaders at all echelons. A perspective on the breadth and depth of this effect is described below from a human performance perspective using four levels of digitization skills.

Equipment Operation

The basic skills for workstation or console operation include keyboarding, pointing/clicking, and navigating in and through a software (usually Windows) environment. Command lines and data base queries need to be routine. In addition, there is a demand for understanding some system functions such as knowing how to reinitialize a system when it crashes, change formats, and do basic troubleshooting.

Equipment Application

Skills at this level involve performing tasks beyond the mechanics of basic program use and navigation. For example, a Military Intelligence (MI) system, such as the All Source Analysis System (ASAS), requires selecting images, defining searches, identifying anomalies, extracting reliable data, computing correlations, and synchronizing message traffic to address a commander's priority intelligence requirements. Setting parameters and conducting searches are tasks added by the computer environment, especially by data base manipulations. The other tasks have always been performed but are far more complicated in the digital world because the potential amount, variety, and speed of data have increased by orders of magnitude. ASAS can receive and store hundreds, conceivably thousands of messages per minute, since it receives electronic data and stores it electronically in a data base without human intervention. The analytic skills to handle this volume are fundamentally different from those for non-digitized systems.

Systems Operation and Integration

At a third level are skills that have to do with understanding the functions of all the human and equipment components within the soldier's sphere of interest or responsibility and how they fit together through digitization. These skills, usually associated with officers and senior staff personnel, have increasing complexity with rank and echelon. A commander will need systems analytic skills to manage combinations of analog and digital operations. He must understand the essential technology underlying digital systems. For example, an officer-in-charge must be facile with capabilities such as tactical systems and network operations, connectivity requirements, and interface parameters for surveillance and targeting systems, as well as the ability to trouble shoot system operating problems under extreme time pressure. In addition, digitization means more emphasis on horizontal and vertical integration of information and operations, providing leaders with more to filter and understand.

Command and Staff Operations

Skills at this level take advantage of digital systems to carry out missions, especially in innovative ways and for situations not anticipated by doctrine and explicit training. The Objective Force will undertake missions that combine combat, peacekeeping, and security

operations not anticipated by doctrine or previous, explicit task training (Kitfield, 1998). For example, in Bosnia, Task Force Eagle (TFE) discovered it could not use JSTARS according to existing doctrine because civilians and combatants, including peacekeepers, were frequently intermingled. Workarounds, involving human intelligence had to be invented (Center for Army Lessons Learned, 1999, p. 52). The term "thinking outside the box" has been used to characterize performance requirements in such an environment. This level of definition imposes a particularly severe challenge to training how best to take advantage of digital systems and procedures.

These four levels of definition represent increasing complexity in the training and use of digital skills. Table 1 shows some of the new demands. The several levels are not, of course, easily distinguishable during military operations since they blend together as jobs are performed. However, they identify the kinds of operational conditions and tasks that form the foundation of necessary training research.

Table 1: What Makes Skills for Digital Systems Different?

Digital systems create new demands and ambiguities, such as:

Equipment Operation

- Task steps are not clearly related to products and have no prescribed order
- Different programs do not have standardized interfaces
- Skills easily perish because of frequent equipment/software changes

Equipment Application

- Graphical user interfaces are not intuitive and require lots of hands on practice
- Personnel must train both on battle tasks and on program recovery and backup
- The scope, volume, and rate of data increase job complexity

System Operations & Integration

- Users need a deep understanding of systems given inadequate documentation
- Networks speed up requirements to coordinate and integrate actions
- Data availability increases decision-making demands

Command & Staff Operations

- Information and communications foster "thinking outside the box," greater risks, and innovation
- Orders have extensive impact and near instantaneous consequences

Appendix B: Challenges Presented by Digitization

To become current on digitization challenges, scientists from the Advanced Training Methods Research Unit at ARI in Alexandria, VA, identified through interviews issues with digitization. They had discussions with senior training personnel at Fort Hood, home of the 4th ID (M), the first digital division. They did extensive interviews with a variety of personnel at the U.S. Army Intelligence Center (USAIC), Fort Huachuca, as well as with officers from one of the light infantry brigades at Fort Drum. USAIC is an important site because the intelligence field is, for the most part, already digitized. The 10th Mountain Division at Fort Drum is important, in contrast, because it is scheduled to begin digitization but had only limited digital equipment at the time of the interviews. Interview results were combined with official and unofficial publications, scientific literature, and discussions among scientists to provide the clusters of issues summarized in Table 2. This became the starting point for determining research topics.

Table 2: Issue Clusters in Training

1. **Operational and Training Environment Constraints:** (a) hybrid/mixed equipment operations, (b) degraded operations, (c) general constraints such as human factors engineering (including equipment weight-to-benefit ratios), motivation and leadership, and time available, (d) on-site digital experts, (e) increased information ratios and complexity, (f) personnel turbulence and retention, (g) dwindling resources.
2. **Training Requirements, in Terms of Tactics, Techniques, and Procedures (TTPs), Tasks, and Skills Needed:** (a) needs and task analyses, (b) multifunctional soldiers, (c) adaptability/thinking "outside the box."
3. **Training Delivery and Support Mechanisms:** (a) availability of training doctrine and good instructional procedures, (b) delivery mechanisms such as Training Aids, Devices, Simulations, and Simulators (TADSS) (simulate/stimulate), platform training, train-the-trainer/master trainer, embedded training, and distance learning, (c) integrating TRADOC's Training Pillars of Institutional, Unit, and Self-development, (d) tradeoffs about what to give up to get what's needed in the time available, (e) where and when to train -- prior to assignment/during assignment.
4. **Training Assessment Support for Trainers:** (a) measurement and feedback for progressive skill levels, (b) recording and transmitting data, (c) competency tests, skill certification, and licenses, (d) obtaining external, objective observers.
5. **Stages of Training:** (a) skill acquisition and sustainment, (b) skill decay and reacquisition, (c) getting to maximum proficiency.
6. **Training Transfer:** (a) across similar and different systems, (b) across specialties (multifunctional), (c) across situations (adaptability).
7. **Individual-Collective Dimensions:** (a) normal and rapid team building, (b) skill development and learning to fight at individual/team/unit levels, (c) developing shared understanding and reconciling different perspectives.

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14. ABSTRACT *(Maximum 200 words)*:

This report outlines challenges about how best to train computer-based digital skills for future battlefield operations. It explains the foundation of Army needs, the state of current knowledge, suggests research to address the most pressing needs, and the potential benefits to the Army. Five training challenges for digitization are identified and discussed: (1) Determine digital task training requirements, (2)Train adaptability, (3) Prepare digitally-linked teams, (4) Assess skill levels of digital soldiers, and (5) Strategies for training on demand. The report's purpose is to communicate with training managers and leaders who have to make informed decisions about how to support training for the Objective Force and the future Army.

15. SUBJECT TERMS

training, individual, team, adaptive; digital systems; skill learning; future Army, Objective Force

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